voluntary observers, and the host of teachers and readers interested in meteorology, the Editor will be pardoned if he occasionally calls general attention to matters that seem to need correction.

The following paragraph occurred in an article recently examined at the Weather Bureau:

When a given mass of air is increased in volume by an access of heat, its capacity for water vapor increases. If a fall of temperature follows, the volume is decreased; condensation sets in, and if the fall of temperature be sufficient, precipitation must occur. But though by this means a large portion of the water vapor of the given mass of air may be precipitated to the earth, the relative humidity of the mass need undergo no special change. That is to say, it may remain as high in the given mass of air, after rain has fallen, as before, unless the temperature again rises; because through shrinkage of volume, less water vapor is needed to keep the percentage of relative humidity high. In those latitudes where, during the winter months, the temperatures are ordinarily low, the volume of air at that season must be considerably less than at other seasons, and its capacity for vapor of water correspondingly diminished.

This quotation contains a number of serious errors, and the sentence could not have been written if its author had seriously considered and accepted the numerous paragraphs bearing on this subject that have appeared from time to time in our columns.

A mass of free air under constant pressure increases its volume by increasing its temperature; but if it is kept under constant volume in a rigid inclosure it increases its elastic pressure against the walls of the inclosure. In the latter case, the accession of heat produces an increase of pressure and temperature; in the former case, it produces an increase of volume and possibly also of temperature. In both cases, there is also an increase in the capacity for water vapor. This latter increase does not depend on either the increase in volume or on the increase in pressure, but on the increase in heat itself. It is not true that the capacity for vapor of water is in proportion to the change in the volume of the air; there may easily be a great increase in capacity with no change in volume—or there may be a great increase in volume but no increase or even a diminution in capacity. The capacity of the free air for moisture depends entirely on the temperature. In fact, the very expression, "Capacity of the air," is itself a mistake. If we give the vapor time enough, it will diffuse among the particles of air just as though there were no air present, but this process is rather slow and usually facilitated by small convection currents, so that in general instead of speaking of the capacity of the air for vapor, we must more properly speak of the capacity of a unit volume of space, or the capacity of a vacuum for vapor.

The capacity of a vacuum for dry air is such that as a pressure of 30 inches and a temperature of 32° F., a cubic foot of space will contain 1.176 ounces of dry air. The capacity of that same vacuous space for vapor at 32° F. is such that when saturated with vapor it will contain 2.11 grains troy, or about 0.004 ounce, and the vapor pressure will be 0.18 inch of the mercurial barometer. If both air and vapor coexist in this cubic foot, we have but to add the above weights and the above pressures, and we find that it contains a total mass of about 1.22 ounces of the mixture at a total pressure of about 30.18 inches. Again, at a temperature of 90°, 1 cubic foot will contain about 1.05 ounces of dry air at a pressure of 30 inches, and about 14.790 grains troy or 0.031 ounce of saturated vapor, exerting a vapor pressure of about 1.41 inches, or 1.08 ounces of the mixture at a total pressure of 31.41 inches. Therefore, by increasing the temperature of the space to such an extent that the air would thereby have its volume increased by about 12 per cent, we have increased the capacity of the space for moisture by about eight times, or about 800 per cent. We have decreased the capacity of the cubic foot to contain dry air, but have increased its capacity to contain moisture. The figures are given in this form, because the ordinary meteorological tables use the cubic foot as a standard, and because the air and the vapor when they attain complete mixture are entirely independent of each other.

But the error of the above-quoted paragraph becomes still more conspicuous if we more strictly follow out the author's erroneous idea that the air, rather than vacuous space, has a capacity for water vapor. The change from 32° to 90° expands the free air from a volume of 1 cubic foot to a volume of about 1.12 cubic feet, whereas it increases the capacity of a cubic foot to contain moisture from 2.11 grains troy up to 14.790 grains, or 700 per cent. Now, as the cubic foot of air has expanded by 12 per cent, we increase the 700 by 12 per cent of itself, or 85, making 785 per cent in all, in order to represent the increased capacity of the original air for vapor, due to the increase both in temperature and volume. It is, therefore, abundantly evident that the idea that the capacity of the air for moisture is in proportion to its increase in volume must be wholly erroneous.—*C. A.*

OCEAN METEOROLOGY.

The above title is really a misnomer, although it has for a long time been in use. It practically means the study of meteorology over the ocean by means of observations made at sea and for the benefit of sailing vessels. But we can not properly have an ocean meteorology and a land meteorology. The atmosphere must be studied as a unit. There is but one meteorology, although there may be ocean observers and land observers, mountain observers and balloon observers, arctic stations and equatorial stations. All these contribute to the general study of the atmosphere which constitutes meteorology.

Early in the history of the Signal Service it was made evident to everyone that the study of our storms and the prediction of the weather could not be successfully prosecuted by means of observations at the surface of the land only; that, in fact, it was absolutely necessary to study both the upper air by means of mountains and balloons and the air above the oceans by means of the ships of the sea. From this point of view the "Bulletin of International Simultaneous Observations" was organized and for the first time in the history of meteorology daily maps for the Northern Hemisphere became possible, and with that began a new epoch in meteorology. Eventually this work was divided, and the Navy Department undertook to care for the ocean while the Weather Bureau cared for the land; but this arrangement had many disadvantages, the publication of the international bulletin and charts ceased, and the study of the atmosphere as a unit was again encumbered with the difficulties attendant upon the want of the daily weather map for the whole earth.

The recent consideration of the great question of the relation of wireless telegraphy to the service of the National Government has incidentally brought about the prospect of a great improvement in the meteorological work of the Government. The Interdepartmental Board on Wireless Telegraphy, recently appointed by President Roosevelt, communicated its unanimous report to him on July 12, and on the 29th he communicated it with his approval to the several departments in turn and directed them to put its recommendations into effect. These latter, therefore, became a part of our departmental regulations, and in so far as they bear on meteorology we quote them from pages 9 and 10 of the "Report of the Interdepartmental Board Appointed by the President to Consider the Entire Question of Wireless Telegraphy in the Service of the National Government, Washington, 1904," as follows:

That the Weather Bureau of the Department of Agriculture furnish to the Hydrographic Office of the Navy, and to the naval wireless telegraph stations, or to other portions of the public service, such meteorological data as it or they may desire at no cost to them.

That the Department of Agriculture shall continue the work of its meteorological vessel-reporting and storm-warning stations, as now con-

stituted and provided for by law, and continue the control of seacoast telegraph systems, except wireless systems.

That all meteorological reports from vessels of war or commerce, or other sailing craft, now being forwarded direct to the Hydrographic Office of the Navy, shall be forwarded direct to the Weather Bureau.

That the estimates for the support of the Hydrographic Office of the Navy, or any other office of the Navy, for the next and succeeding years, do not contain any provision for the making of ocean forecasts, or for the publication of meteorological data, other than such as may be needed by the Hydrographer of the Navy for use on the pilot and other charts, which data shall be furnished by and credited to the Weather Bureau.

That it is the opinion of this board that no meteorological work need or should be done by any portion of the Navy for the purpose of publication or for the making of forecasts or storm warnings; that all such duties, being purely civil, should devolve upon the Weather Bureau of the Department of Agriculture in accordance with the organic act creating that Bureau.

That the wireless stations of the Navy shall, without charge to the Agricultural Department, receive and promptly transmit to the ocean or to islands, or to other places where the information can be made useful, the storm warnings of the Weather Bureau.

That the Navy Department shall request all vessels having the use of its wireless stations for the receipt of messages to take daily meteorological observations of the weather when within communicating range and to transmit such observations to the Weather Bureau, through naval wireless stations, at least once daily, and transmit observations oftener when there is a marked change in the barometer, and that there shall be no charge against the Agricultural Department for these observations or for the transmission thereof.

C. A.

TEMPERATURE OF THE UPPER ATMOSPHERE.

The most important congress of scientific men that has ever been held will convene in St. Louis under the presidency of Prof. Simon Newcomb on September 18–25. Meteorology will not occupy a very prominent place in this convention, owing to the inability of several distinguished men to accept the invitation to be present; fortunately, however, one of the most distinguished authorities in cosmical physics, Prof. Svante Arrhenius, is to be present, and his address will probably be as important as was the recent publication of his volume of lectures on this subject. During his preliminary travels in this country this eminent scientist seems to have spent some time at the Lick Observatory, where he has written a paper, dated August 1, "On the Physical Nature of the Solar Corona," which is published as No. 58 of the bulletins of the Lick Observatory. In this he shows that both optical, photographic, and bolometric measurements harmonize in showing that the dust particles of the corona, or the drops of liquid particles of molten metals, if such they be, should, by reflecting the sun's light and heat, produce just the phenomenon that we actually observe, and lead to an approximate determination of the total mass within a cubic meter of the substance of the corona. At the close of this bulletin Arrhenius makes the following remark with regard to the temperature of the earth's atmosphere as deduced from analogous calculations relative to the dust in our atmosphere as warmed up by radiation from the sun and the earth, but cooled by their own radiation into space. Nothing is said by him about the conduction of heat between this dust and the adjacent air. If that would be allowed for, the train of argument would be more complete.

It is often supposed that the outermost layers of the sun are of an exceedingly low temperature, due to the adiabatic dilation of the sun's gases from their vertical circulation. Just in the same manner one calculates that the highest strata of the earth's atmosphere should have an exceedingly low temperature.

The spectroscopic evidence for the sun gives a totally different idea of the temperature in its upper strata. This depends upon two circumstances. The radiation of the sun is extraordinarily strong. In the higher strata the density and consequently the heat capacity of the gases sink to the lowest limit. Therefore their expansion, with the lowering of the temperature in ascending, is wholly overwhelmed by the strong radiation, and we may calculate the temperature as determined by the radiation alone, as we have done above, without committing any sensible error.

This probability also holds good for the uppermost extremely thin strata of the earth's atmosphere, especially on the insolated side of the earth. These highest strata contain particles of cosmical dust, supposed to swim by help of the repulsion of their negative electric charges from the electric charge of lower strata. On account of the insolation, the temperature of these dust particles reaches about 57° C. if the temperature of the soil below is about 30° C.,[1] as is easily calculated by the formula of Stefan. Also, on the night side of the earth, by the radiation of the earth, these particles will get a temperature $\sqrt[4]{2}$ times lower than that of the soil. If this is assumed to be 15° C., one finds, for the dust particles in the highest strata, —31° C. Now, one has observed much lower temperatures in lower strata up to about 20 kilometers. It is, therefore, probable that our atmosphere at a certain height reaches a minimum of temperature, and that at higher strata the temperature again increases. Especially is this valid for the insolated part of the earth, on which the highest temperatures, according to this opinion, occur in the highest strata of the atmosphere, and not, as is generally supposed, in the lowest layers of it.

These conclusions are in excellent agreement with the results of the most modern researches, by Teisserenc de Bort and Assmann, of the temperature of the highest investigated strata of the air.

PRECIPITATION IN WISCONSIN.

Mr. W. M. Wilson, Section Director, Milwaukee, Wis., communicates copies of an address on the work of the United States Department of Agriculture and another on the work of the United States Weather Bureau, delivered by him at the Farmers' Institute held at Oconomowoc, Wis., in March, 1902. These are published in Bulletin No. 16 of the Wisconsin Farmers' Institute, and seem to have attracted favorable attention. In the course of the latter address, Mr. Wilson defended the idea that there has been no material change in climate since meteorological records began to be kept in the State of Wisconsin. By this he explained that he referred especially to the annual rainfall and its fluctuations. Thus he finds from the record of thirty-six years at Beloit that during the last ten years the precipitation has been decidedly more than for the first ten years of this period. On the other hand, the record for thirty-nine years at Manitowoc shows that the average precipitation for the last ten years of this period is decidedly less than for the first ten years. It is, therefore, impossible to infer that there has been any change in the annual rainfall for Wisconsin.

A discussion of this subject by those present at the institute brought out the view that this was not a satisfactory conclusion; that, in fact, we may have the same number of inches of rainfall at different periods and yet have a change in the climate. Annual rainfall is not the controlling climatic consideration. The climate may have changed so far as concerns its influence in the growth of corn and other special matters in which farmers are interested. Mr. Reitbrock stated that fifty-five years ago we considered Waterford, 25 miles south of Milwaukee, as the northern limit of the corn belt. But now we know that corn can succeed on the Lake Superior slope of the Penokee range of mountains. A climatic change has been going on, due to the fact that this territory was all forests in former years and the sun could not melt the ice and snow as rapidly as it can now. The ground warms up more rapidly in the southern part of the State since the timber has been all cut off. The value of rainfall to the crops depends upon seasonal distribution and the frequency of showers in the growing season. A few inches of moisture in summer properly distributed may raise a crop where twice the amount in one or two heavy storms may leave us with no crop.—*C. A.*

CANNONADING AGAINST HAIL.

Among the special commissions in the war office of the French Government is one on powder and saltpeter. This commission has lately published a memoir in which there appears, among other things, a report by Angot on the experiments made to prevent hail by cannonading. Although this subject has been settled as far as American practise is concerned, and will doubtless soon be buried and forgotten in

[1] Above a soil of 0° C. it would be 47° C.